

Europäisches Patentamt  
European Patent Office  
Office européen des brevets



(11) **EP 1 062 911 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
27.12.2000 Bulletin 2000/52

(51) Int. Cl.<sup>7</sup>: **A61B 6/00**

(21) Application number: **00113050.9**

(22) Date of filing: **23.06.2000**

(84) Designated Contracting States:  
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU  
MC NL PT SE**  
Designated Extension States:  
**AL LT LV MK RO SI**

(30) Priority: **24.06.1999 JP 17774099**

(71) Applicant: **Alcare Co., Ltd.**  
**Sumida-ku, Tokyo (JP)**

(72) Inventors:  
• **Hirano, Hiroyuki**  
**Funabashi-shi, Chiba-ken (JP)**  
• **Takekawa, Naomitsu**  
**Itabashi-ku, Tokyo (JP)**

(74) Representative:  
**Klingseisen, Franz, Dipl.-Ing. et al**  
**Patentanwälte,**  
**Dr. F. Zumstein,**  
**Dipl.-Ing. F. Klingseisen,**  
**Postfach 10 15 61**  
**80089 München (DE)**

(54) **A marker for computer tomography or MRI imaging**

(57) A marker for each of images for CT photographing, MRI photographing, and CT/MRI photographing is obtained. A marker formed into a solid or hollow bar formed of silicon resin and/or fluorocarbon resin shows sufficient X-ray absorption in CT photographing, and thus it becomes a CT marker. Elastomer such as styrene isoprene styrene copolymer and so forth, and organogel such as polyethylene gel and so forth output high signals in both T1-weighted spin-echo images and T2-weighted spin-echo images of MRI photographing and appear clearly on images, thus they become MRI marker. One wherein material for MRI is filled into said tube shaped CT marker does not interfere with each other, thus may be employed as both a CT marker and an MRI marker. Since it is possible to carry out CT photographing and MRI photographing without exchanging markers, it is feasible to specify the position and so forth of a focus concerned with fewer errors on images and in a more precise manner.

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## Description

### BACKGROUND OF THE INVENTION

#### Field of the Invention

**[0001]** The present invention relates to a marker for image photographing to be used in CT photographing and MRI photographing.

#### Background Information

**[0002]** In the medical treatment for focuses such as tumors and so forth in patients brains and bodies, widely conducted is radiotherapy, where radioactive ray is irradiated from outside of the body. In this radiotherapy, it is effective to minimize irradiation amount onto normal tissues (cells) while to irradiate a large amount of radioactive ray onto focuses concerned. For this purpose, it is necessary to irradiate a small exposure dose of radioactive ray onto focuses precisely from multiple directions.

**[0003]** In practice of such radiotherapy, it is required to make a medical treatment plan on irradiation positions, irradiation directions, exposure dose, exposure times and so forth. For making such a plan, it is indispensable to make out the size of a focus concerned in the body and the 3-dimensional position thereof in a precise manner.

**[0004]** In such medical treatment plans, at present, Computed Tomography (CT) photographing using radioactive ray is carried out to investigate the size and position of a focus, and in photographing, a marker is used, and changes in positions of marker and focus displayed on images of laminagram are read and reconfigured to specify the position and so on of a focus concerned.

**[0005]** Conventionally, as such CT marker, a metallic wire has been employed from characteristics of X-ray absorption, it is true that this conventional marker appears clearly on CT images. However, as a wire may damage portions of patient, thus it has been dangerous. It will rust in long term service, and accordingly it has poor durability, and has high fear of contamination, as a result, metallic wire as CT marker has been far from satisfaction in the art.

**[0006]** In practice of the above medical treatment plans, also conducted is Magnetic Resonance Imaging (MRI) photographing, and in this case too, results of tomography using marker are reconfigured in the same manner as stated above so as to specify the size and position of a focus concerned.

**[0007]** Generally, in MRI there is not so significant difference between the proton density of normal tissues and that of focuses, while there is a significant difference between their respective relaxation time. This relaxation time has two factors, i.e., longitudinal relaxation (T1) and transverse relaxation (T2), T1 and T2 in

general have nature to offset signal strength, consequently, it is necessary to separately photograph images where T1 is emphasized (T1-weighted spin-echo images) and images where T2 is emphasized (T2-weighted spin-echo images).

**[0008]** Conventionally as marker for this T1-weighted spin-echo images, margarine, salad oil, water solutions of paramagnetic materials and so forth have been employed, while water has been employed as marker for T2-weighted spin-echo images. The markers must be changed prior to respective cases of photographing T1-weighted spin-echo images and T2-weighted spin-echo images, which in turn leads to deteriorated precision in positioning a focus concerned, and further makes handling markers and photographing complicated and troublesome. These have been the problems with the conventional art in the present field.

**[0009]** Accordingly, we formerly provided markers wherein paramagnetic material was added uniformly into viscous liquid and gel hydrophilic substance, which enabled to photograph both T1- and T2-weighted spin-echo images. Furthermore, the present invention aims at making them easier to use, and give them more excellent durability.

### SUMMARY OF THE INVENTION

**[0010]** Accordingly, it is an object of the present invention to obtain a marker for CT image photographing, which is safer and more durable than the conventional CT markers, and appears clearly on images from the preferable absorption thereof.

**[0011]** Another object of the present invention is to obtain a marker for CT image photographing, which is still safer and more durable, which outputs high signals to both T1 and T2-weighted spin-echo images of MRI and responds to both of them.

**[0012]** It is still another object of the present invention to obtain a marker that can be employed for both CT and MRI, which enables to conduct CT image photographing and MRI (T1, T2) image photographing by use of a single marker.

**[0013]** The present invention has been completed on the basis of the knowledge that we found in our search for a new CT marker to replace the conventional metallic wire, that silicon resin and fluorocarbon resin appeared clearly on CT images.

**[0014]** And as a marker for MRI, we found that elastomer of rubber and so forth, and organogel of polyethylene gel and so forth output high signals in response in photographing T1 and T2-weighted spin-echo images, and appear clearly on images, thereby obtaining an MRI marker having excellent durability.

**[0015]** Still further, a combination of the above CT marker and MRI marker enables to obtain clear images in photographing all the CT, T1 and T2 in MRI images without mutual image interference. Accordingly it enables a single marker to be employed in both the above

CT and MRI image photographing operations.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

**[0016]** In photographing CT images, CT parameters are generally employed, and these CT parameters are determined by the absorption dose of X-ray used, so the values vary from -1000 to +1000, wherein CT parameter for air is -1000, that for water is 0, and that for a matter which absorbs all is defined as +1000. In general, CT parameter of bone varies from +300 to +1000, and that of soft tissues is around -80 to -50, while that of brain or liver as objects in normal diagnosis appears from +35 to +100, and that of lungs appears from -800 to -700, as a consequence, it is preferable for a marker to have CT parameter at least over 0, and preferably over 60.

**[0017]** The CT parameter of the silicon resin mentioned above is around from +130 to +230, and that of the fluoroethylene resin mentioned above appears nearly same, therefore, they can show clear images in photographing CT images. In addition, these two resins may be employed together at the same time at necessity.

**[0018]** It is preferable that these CT markers are normally employed in the form of solid bars with diameter about 1 ~ 6 mm, preferably about 2 ~ 4 mm, and the shape of such bars in specified length enables to insert them into insertion hole arranged in a brain stereotactic radiosurgery, brain stereotactic mask, and other diagnostic patient restrainers and to easily position them. Further they will not damage patients, and will not rust, therefore, they have excellent durability too. Moreover, these CT markers may be formed into hollow bars.

**[0019]** In MRI photographing, as a marker to respond to both the above T1-weighted spin-echo images and T2-weighted spin-echo images, elastomers are available in single or in combination: elastomers of styrene isoprene styrene copolymer (SIS), styrene ethylene butylene styrene copolymer (SEBS), styrene ethylene propylene styrene copolymer (SEPS), isoprene rubber (IR), isobutylene isoprene rubber (IIR), natural rubber (NR) and so forth. And as organogel, available in single or in combination are organogel of polyethylene gel, acrylic gel, urethane gel and so forth. The above elastomer and organogel may be used in combination at necessity.

**[0020]** The above polyethylene gel is one wherein a plasticizer is mixed into ethylene styrene copolymer. As plasticizer are employed liquid paraffin, mineral oil, phthalic acid plasticizers such as butyl benzyl phthalate (BBP), di-octyle phthalate (DOP), di-butyl phthalate (DBP), di-iso nonyl phthalate (DINP) and so forth, soy bean oil, and fatty acids such as oleic acid, linoleic acid and so forth.

**[0021]** The above acrylic gel is firstly copolymerized by such main compounds as 2-ethyl hexyl acrylate, butyl acrylate, methyl acrylate, methyl methacrylate and

so forth with acrylic acid, methacrylic acid, vinyl acetate and so forth. And plasticizer are added thereto, and crosslinked by chemical compounds such as isocyanate, aziridine, epoxy system and so forth. As plasticizers are used: those similar to those employed in the above polyethylene gel.

**[0022]** The above urethane gel is a gel of urethane resin plasticized by phthalic acid type plasticizer employed in the above polyethylene gel, or a gel of urethane resin polymerized by polyisocyanate and polyole with molecular weight above about 3000.

**[0023]** As these, taken up are, for example, Cosmogel (polyethylene gel of ethylene styrene copolymer plasticized by liquid paraffin, manufactured by Cosmo Instruments Co., Ltd.), Saivinol AT-304 (acrylic gel, manufactured by Sainen Chemical Industry Co., Ltd.), and so forth.

**[0024]** The elastomer and organogel is filled into a tube or contained into bar shape by a sheet. The tube or sheet is formed of materials that do not affect on T1 and T2-weighted spin-echo images of MRI, for instance, nylon, polyester, polypropylene, polyvinyl chloride and so forth. The tube or bar having elastomer and organogel may be used conveniently in the same manner as stated in the above CT image photographing. And they may be formed into bar shape or so by use of mold.

**[0025]** While the inventors tried combinations of elastomers and organogels that may be used as the above MRI marker, and those that may be employed as the above CT marker, the inventors found that above combination attained appropriate X-ray absorption in CT photographing, and they output high signals in both T1 and T2 of MRI, thus they do not interfere with each other in both CT photographing and MRI photographing.

**[0026]** Namely, the combination marker has sufficient sensitivity as a marker for both CT photographing and MRI photographing when the material for the above MRI marker is filled into a hollow tube formed of a material that may be employed as the above CT marker.

**[0027]** In this case, the material for MRI marker may be contained by the material for the above CT marker, or both the materials may be laminated, or formed into bar shapes and so forth.

**[0028]** In the CT photographing mentioned above, it is easy to make out the position of a focus concerned but difficult to make out the shape thereof, while in MRI photographing, wherein there is image distortion peculiar to MRI, it is easy to make out the shape and size of a focus concerned, but difficult to make out the position thereof. The use of the above marker that responds to both above CT photographing and MRI photographing enables to carry out CT photographing with this marker fixed onto a patient, and then carry out MRI photographing without replacing this marker with other. Accordingly, it is possible to prevent displacement in both the CT and MRI images, and to make out the position, shape, and size of a focus concerned in a more precise manner.

**[0029]** And in these years, the development of open magnetic resonance imaging and the progress of computer software have enabled to obtain images wherein distortion of MRI images are revised. In creating synthetic images from these MRI images and CT images, the marker according to the present invention may greatly help increase precision more, and make more appropriate medical treatment plans.

**[0030]** The invention is illustrated in more details by reference to the following referential examples and preferred embodiments hereunder.

#### EXAMPLE 1

**[0031]** A marker of solid silicon cylindrical bar shape with diameter 2 mm and length 10 cm was prepared.

**[0032]** CT photographing was conducted by use of this marker, and it has been found that this marker has sufficient absorption and consequently appears clearly on CT images, which shows it is useful as a CT marker.

#### EXAMPLE 2

**[0033]** Cosmogel IC00N (polyethylene gel manufactured by Cosmo Instruments Co., Ltd.) was heated up to 130°C and melt, and then suctioned and filled into a polypropylene tube with inner diameter 2 mm and outer diameter 3 mm, and then cooled down to prepare a marker with length 10 cm.

**[0034]** MRI photographing was carried out by use of this marker, and it has been found that this marker outputs high signals to both T1-weighted spin-echo images and T2-weighted spin-echo images and accordingly appears clearly on both the images, which shows it is useful as an MRI marker.

#### EXAMPLE 3

**[0035]** Cosmogel IC00N was heated up to 130°C and melt, and then suctioned and filled into a silicon tube with inner diameter 2 mm and outer diameter 3 mm, and then cooled down to prepare a marker with length 10 cm.

**[0036]** CT photographing was carried out by use of this marker, and it has been found that this marker has sufficient absorption and consequently appears clearly on CT images. And also MRI photographing was carried out by use of this marker, as a result this marker output high signals to both T1-weighted spin-echo images and T2-weighted spin-echo images and accordingly appeared clearly on both the images. This single marker is useful for both CT and MRI (T1, T2) marker.

#### EXAMPLE 4

**[0037]** Saivinol AT-304 (acrylic gel manufactured by Sainen Chemical Industry Co., Ltd.) was applied onto a

released paper. And its solvent was volatilized, thereby dry acrylic gel of thickness 500μm was manufactured, and then a silicon sheet of thickness 1mm was laminated onto the above dry acrylic gel. And the released paper of acrylic gel was peeled off, and further a silicon sheet of thickness 1mm was attached onto the acrylic gel. Then the acrylic gel was sandwiched by silicon sheets, and was cut, thereby a bar shaped marker with width 3 mm and length 10 cm was made.

**[0038]** As a result, this marker output high signals to all of CT images by CT photographing, T1-weighted spin-echo images and T2-weighted spin-echo images by MRI photographing and appeared clearly on each of those images, thus it has been found that this marker is useful as both CT and MRI marker.

**[0039]** As mentioned heretofore, CT marker according to the present invention shows appropriate X-ray absorption in CT photographing and appears clearly on images. This does not have such fear of damage on patients as the conventional metallic wire does, therefore, it is feasible to obtain a marker that may be used in a safer manner for a long period.

**[0040]** And further MRI marker according to the present invention outputs high signals in both T1-weighted spin-echo images and T2-weighted spin-echo images in MRI photographing and accordingly appears clearly on images. It has excellent storage property and durability since it is made of elastomer and organogel.

**[0041]** Moreover, a combination of the above CT marker and MRI marker appears clearly on images without interfering with each other in both CT photographing and MRI photographing, and still further there is no need to exchange markers for each of these photographing operations, accordingly, it is possible to prevent displacement in both the CT and MRI images. Consequently it may be easily understood by those skilled in the art that it is feasible to obtain images marked with high precision, thereby it is feasible to make more appropriate medical treatment plans.

**[0042]** The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

#### **Claims**

1. A CT marker for image photographing, characterized by being formed of silicon resin and/or fluorocarbon resin.
2. A CT marker for image photographing according to claim 1, characterized by being formed into a solid or hollow bar of said silicon resin and/or fluorocarbon resin.

bon resin.

3. An MRI marker for image photographing, characterized by being formed of elastomer and/or organogel. 5
4. A CT/MRI marker for image photographing, characterized by that elastomer and/or organogel is filled and sealed in a hollow bar formed of silicon resin and/or fluorocarbon resin. 10
5. A CT/MRI marker for image photographing, characterized by that part or whole of the circumference of a bar of elastomer and/or organogel is covered with silicon resin and/or fluorocarbon resin. 15

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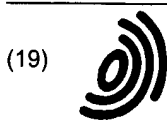
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(11) **EP 1 062 911 A3**

(12) **EUROPEAN PATENT APPLICATION**

(88) Date of publication A3:  
07.11.2001 Bulletin 2001/45

(51) Int Cl.<sup>7</sup>: **A61B 19/00**, A61B 6/12,  
A61B 5/055, G01R 33/28,  
A61B 6/00

(43) Date of publication A2:  
27.12.2000 Bulletin 2000/52

(21) Application number: **00113050.9**

(22) Date of filing: **23.06.2000**

(84) Designated Contracting States:  
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU  
MC NL PT SE**  
Designated Extension States:  
**AL LT LV MK RO SI**

• **Takekawa, Naomitsu**  
Itabashi-ku, Tokyo (JP)

(30) Priority: **24.06.1999 JP 17774099**

(71) Applicant: **Alcare Co., Ltd.**  
Sumida-ku, Tokyo (JP)

(74) Representative:  
**Klingseisen, Franz, Dipl.-Ing. et al**  
Patentanwälte,  
Dr. F. Zumstein,  
Dipl.-Ing. F. Klingseisen,  
Postfach 10 15 61  
80089 München (DE)

(72) Inventors:  
• **Hirano, Hiroyuki**  
Funabashi-shi, Chiba-ken (JP)

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# EUROPEAN SEARCH REPORT

Application Number  
EP 00 11 3050

DOCUMENTS CONSIDERED TO BE RELEVANT					
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)		
X	US 4 916 170 A (NAMBU MASAO ET AL) 10 April 1990 (1990-04-10) * abstract; claims 1-3; figure 3 * * column 8, line 43 - column 9, line 38 * ---	1-5	A61B19/00 A61B6/12 A61B5/055 G01R33/28 A61B6/00		
E	WO 00 38579 A (BUSH MARY ELIZABETH & CONSTON STANLEY R (US); FAWZI NATALIE V (US);) 6 July 2000 (2000-07-06) * page 8, line 23 - page 9, line 12 * * page 14 * * page 17 * * page 19 - page 20 * * figures 1,2 * ---	1-5			
X	US 4 951 673 A (LONG DAVID M) 28 August 1990 (1990-08-28) * abstract * * column 8, line 13-17 * ---	1-5			
A	PATENT ABSTRACTS OF JAPAN vol. 1998, no. 11, 30 September 1998 (1998-09-30) & JP 10 165391 A (JAPAN FOCUS KK; SONDERLEGER MARSEL), 23 June 1998 (1998-06-23) * abstract * -----	1-5	<table border="1"> <thead> <tr> <th>TECHNICAL FIELDS SEARCHED (Int.Cl.7)</th> </tr> </thead> <tbody> <tr> <td>A61B G01R A61K</td> </tr> </tbody> </table>	TECHNICAL FIELDS SEARCHED (Int.Cl.7)	A61B G01R A61K
TECHNICAL FIELDS SEARCHED (Int.Cl.7)					
A61B G01R A61K					
The present search report has been drawn up for all claims					
Place of search <b>BERLIN</b>		Date of completion of the search <b>13 September 2001</b>	Examiner <b>Jonsson, P.O.</b>		
<table border="0"> <tr> <td style="vertical-align: top;"> <b>CATEGORY OF CITED DOCUMENTS</b>            X : particularly relevant if taken alone            Y : particularly relevant if combined with another document of the same category            A : technological background            O : non-written disclosure            P : intermediate document         </td> <td style="vertical-align: top;">           T : theory or principle underlying the invention            E : earlier patent document, but published on, or after the filing date            D : document cited in the application            L : document cited for other reasons            &amp; : member of the same patent family, corresponding document         </td> </tr> </table>				<b>CATEGORY OF CITED DOCUMENTS</b> X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document	T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document
<b>CATEGORY OF CITED DOCUMENTS</b> X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document	T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document				

EPO FORM 1503 03/82 (P4/C01)



European Patent  
Office

Application Number

EP 00 11 3050

### CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

- ☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claim(s):
- ☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

### LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

- ☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.
- ☒ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.
- ☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:
- ☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:





European Patent  
Office

**LACK OF UNITY OF INVENTION  
SHEET B**

Application Number  
**EP 00 11 3050**

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

**1. Claims: 1,2,4(part),5(part)**

A CT marker formed from silicon resin

**2. Claims: 3,4(part),5(part)**

A MRI marker formed of elastomer

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 00 11 3050

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
The members are as contained in the European Patent Office EDP file on  
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13-09-2001

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EPO FORM P0489

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82